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SOIL AND WATER CONSERVATION RESEARCH

in the Pacific Northwest

Miscellaneous Publication No. 923

Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

Soil, Water, and the Conservation Team . . .

Soil and water are the Nation's two most vital natural resources. Orderly and wise development and conservation of these resources depend on the efforts and interests of many groups. Collectively, these groups are called the *Soil and Water Conservation Team.* This team includes farmers, ranchers, Soil Conservation District personnel, technicians, teachers, extension workers, economists, and research workers.

To be effective, this teamwork must reflect a background of sound technical information. Research has provided this pool of knowledge. Practices now being applied represent the results gleaned from many years of experience.

But we need to know more. Our expanding population and the consequent demands for more food and fiber have created new problems in the management and use of soil and water. Facts gained from research today will provide the bases for conserving soil and water tomorrow.

Washington, D.C. Issued August 1963

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SOIL AND WATER CONSERVATION RESEARCH

in the Pacific Northwest

Prepared by the Soil and Water Conservation Research Division, Agricultural Research Service

Soil and water conservation research in the Pacific Northwest covers a wide range of problems. Major emphasis is devoted to three general areas of research.

On semiarid sagebrush-rangeland watersheds, research emphasizes the hydrology of such areas. Detailed studies are conducted to determine both the characteristics of precipitation and the ultimate disposition of it—whether to runoff, evaporation, transpiration, or ground water supplies. Similar studies are conducted on sediment—its source areas, transport overland and in channels, and deposition in ponds, streams, or elsewhere. Results of these studies are used to develop useful mathematical relationships between various watershed properties and water supply and sediment production phenomena.

On nonirrigated grainlands, studies emphasize various tillage and cropping practices and fertility requirements. The results provide information leading to recommendations for controlling runoff and erosion and for making maximum use of available moisture supplies.

On irrigated lands, engineering and soil management studies are aimed toward (1) maximum efficiency in use of water and labor, (2) elimination of drainage and salinity or other adverse soil problems, and (3) determining the best management practices on major irrigated soils of the region. Again, much of the effort is concerned with developing criteria, instrumentation, and equipment to improve the design of both surface and sprinkler irrigation systems. Other specialized studies include the infiltration and moisture storage properties of soils, the chemistry of organic matter and plant nutrient elements in soils, and the microbiologic properties of soils.

This publication describes a few examples of recent soil and water conservation research. Scientists and engineers of the Soil and Water Conservation Research Division, Agricultural Research Service, cooperate with the personnel of the State agricultural experiment stations in developing all phases of the research program.

SOIL EROSION CONTROL METHODS

Soil erosion is a serious problem on wheatlands of the Pacific Northwest. Steep and rolling topography, winter precipitation, and necessity for the summer fallow system are major complicating factors. Sediment deposition in lower lying areas is a byproduct of the problem. Erosion removes soil material and deposits it in streams, waterways, and on more level parts of fields.

Plot studies are used to great advantage in studying management practices to control erosion. Water and soil coming from the plots are collected and measured at the downslope end of the plots. Variables such as tillage, crop cover, and residue management can be effectively evaluated in side-by-side comparison prior to final evaluation in larger field studies. On the plots shown here, various methods of managing crop residues are being compared.

Some types of treatment must be evaluated on field scale plots because of the confounding influences of confining water to narrow plots. Here, a practice called "vertical mulching" is under study. Wheat straw is mowed and windrowed on the contour. A vertical mulching machine chops the straw and blows it into a trench formed by a chisel point. The straw holds the trench open and potential runoff water percolates into the trench through the porous straw-filled channel and is absorbed by the soil.

Excessive tillage is a major cause of erosion in the Northwest, as shown on this seedbed prepared in the conventional manner for wheat following peas. Two or three extra tillage operations are required to prepare a "manicured" surface that many have thought was necessary to obtain a good stand of wheat. These extra operations cost from $3 to $5 per acre.

This is a cloddy seedbed as it appears prior to seeding. Wheat is drilled directly in this cloddy surface. Sometimes one tillage operation with a springtoothed harrow or skew treader is necessary if clods are too large and hard.

Here is a side-by-side comparison of wheat on a conventionally prepared seedbed (left) and a cloddy seedbed (right). Stooling of the wheat plants makes up for the more sparse stand on the cloddy seedbed, and yields on each treatment are nearly equal.

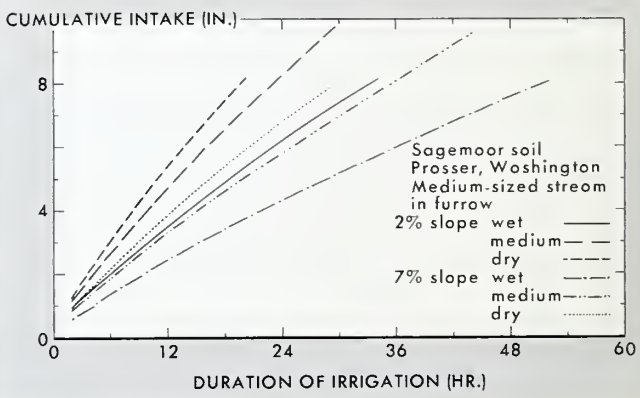
IRRIGATION SYSTEM DESIGN AND WATER MANAGEMENT

Proper design of irrigation systems and management of irrigation water are essential for efficient use of limited irrigation water supplies. These experiments at Prosser, Wash., are designed to study the effect of length of run, furrow slope, and size of stream in the furrow on water intake, furrow erosion, and water application efficiency. Variables studied also include furrow spacing, soil moisture at time of irrigation, and type of crop. The difference in runoff from furrows is due to different size streams applied at upper end of field.

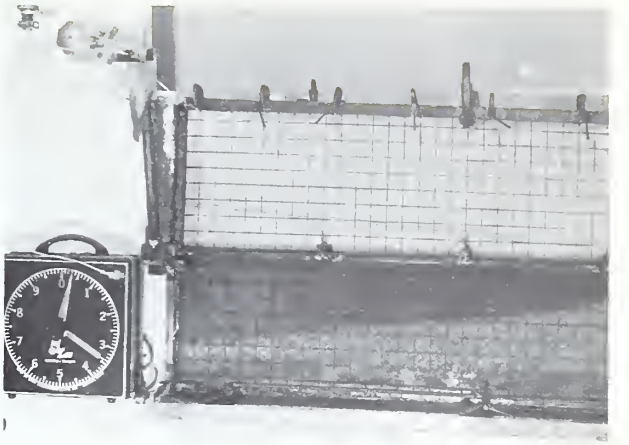
Water is carefully measured onto and off each plot with equipment such as shown here. Rate of advance of the water down the furrow and velocity of flow in the furrow are precisely measured. Amount of soil eroded from the plot is measured by sampling the runoff.

From the measurements, charts can be developed to indicate the length of time required to add any given amount of water to the soil under specified conditions of soil, crop, slope, stream size, furrow spacing, and initial moisture condition. Susceptibility of the soil to erosion and basic information concerning the furrow erosion process are also products of this type of research.

WATER INTAKE OF ROW CROPS



Many irrigation design criteria can be established through model studies. Soil material is placed in the bottom half of this glass-walled model; glass wool is packed in the top half. Then an appropriate slope is established and water introduced at the left side. The glass wool retards water flow across the surface and thus simulates flow for a longer section of an irrigation run. Progress of the wetting front can be observed visually (dark-light boundary in soil) and the shape and slope of the water surface can be measured.



Sprinkler systems are also studied. Various line and sprinkler head spacings and different sprinkler heads and nozzles are tested to find the best combinations for maximum efficiency of water distribution. Catch cans are placed at intervals in the sprinkler pattern to evaluate the distribution of water. Then soil moisture is determined. Effects of wind, humidity, and other factors can also be studied by this technique. The tractor-mounted hydraulic sampler is used to obtain soil samples for measuring the distribution of moisture in the soil after irrigating.

Accurate measurement of soil moisture is an essential feature of irrigation water management research. The neutron soil-moisture meter shown here is a highly valuable research tool. It measures precisely and quickly the amount and distribution of moisture in the soil without disturbing the soil.

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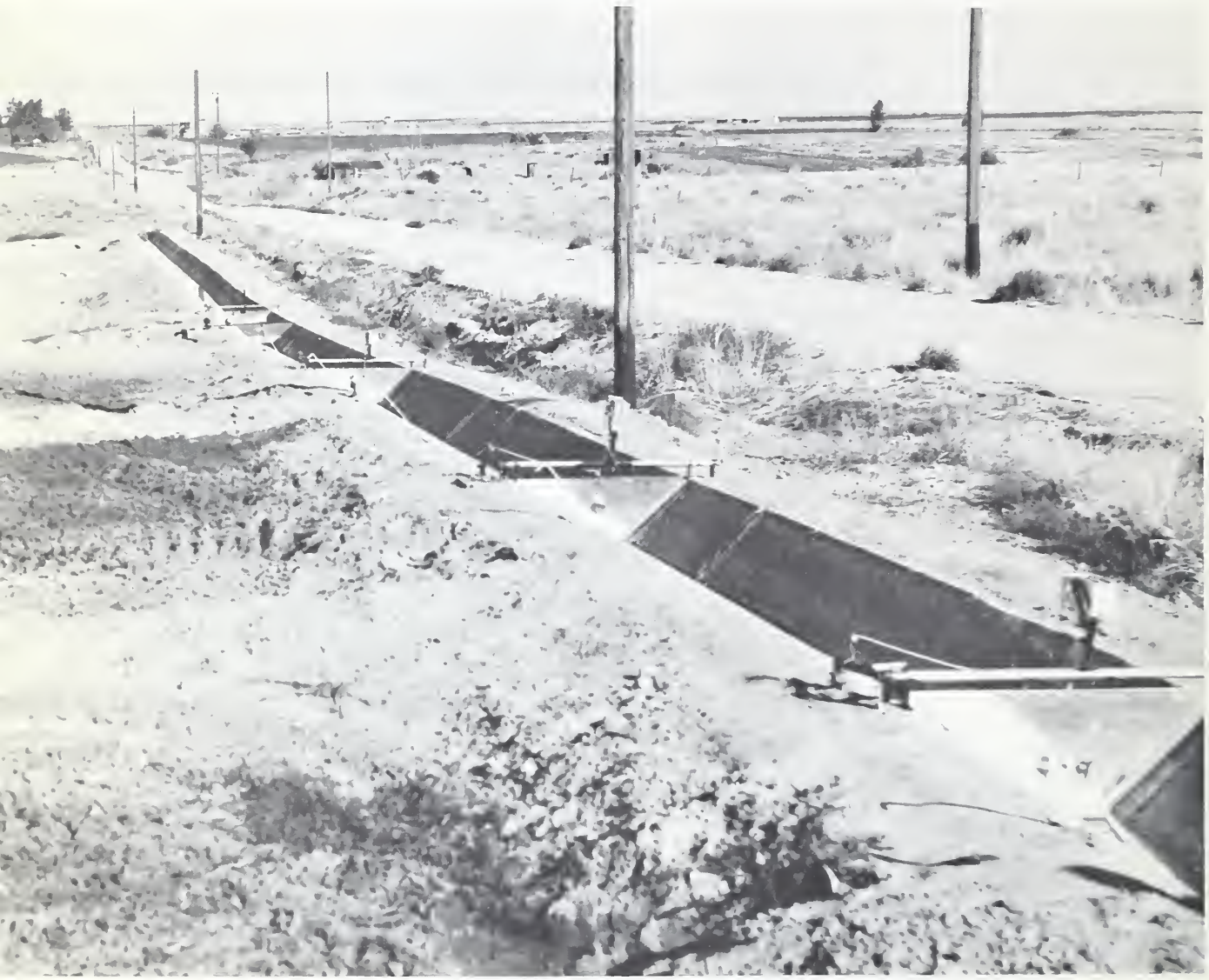
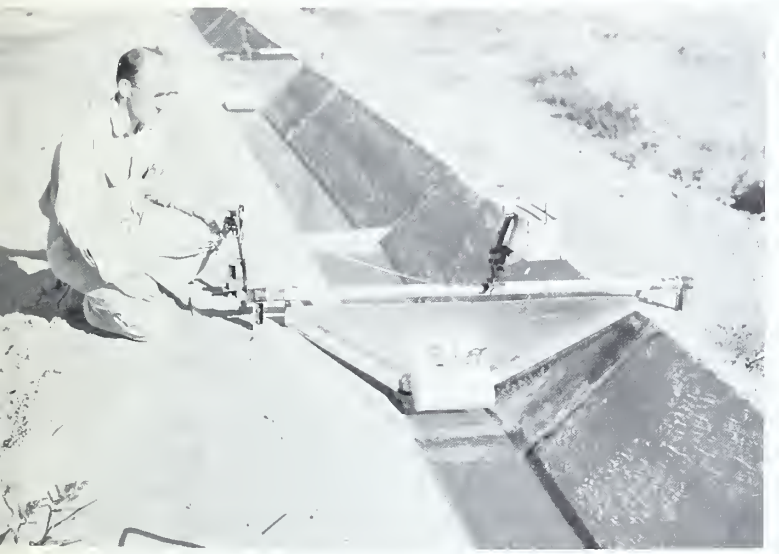
High labor cost in applying irrigation water has been a great deterrent to application of good water management on the farm. This picture shows automatic devices under test in the field. The gates automatically change the water from one border to another on a predetermined schedule without attention by the operator.



Several types of gates have been developed. This "sinking float" type has a counterweight in the box at the top to hold the gate open slightly when water is not in the ditch. A float attached to the back side holds the gate completely open when water enters the ditch. Holes in the bottom of the float admit water at a rate controlled by a small air vent in the top of the float. When the float sinks, the force of the water automatically closes the gate. Controlling the rate of air release serves to control the time during which water is allowed to pass through the gate.

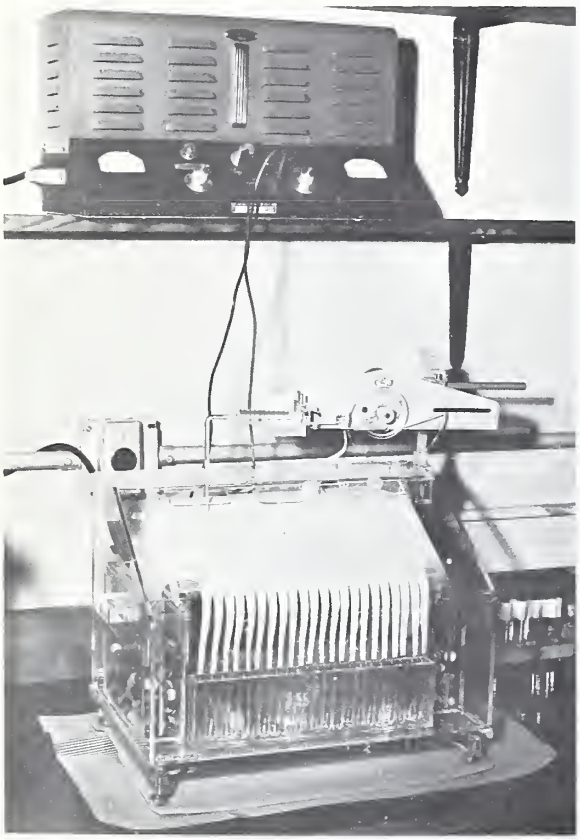


This mechanically operated gate is called the "water clock" type. The gate is closed when the water is turned on. When water enters the ditch, a small hole near the middle of the gate lets water leak into a container attached to the back side. When enough water leaks through, the weight of the container trips the release mechanism and the gate opens. The float on the front of the gate holds it open as long as water is in the ditch. When water is removed, the counterweight at the top forces the gate closed and it is in position for the next irrigation.

This third type is called an "overflow release gate." The gate is closed initially and a sinking float gate allows water to pass onto the field. When the sinking float gate closes, water rises in the ditch and overflows the notch in the main gate into a container attached to the back of the gate. A float rises with the water in this container and trips the release mechanism. When water is removed from the ditch, the gate closes in the same way as the water clock type above.

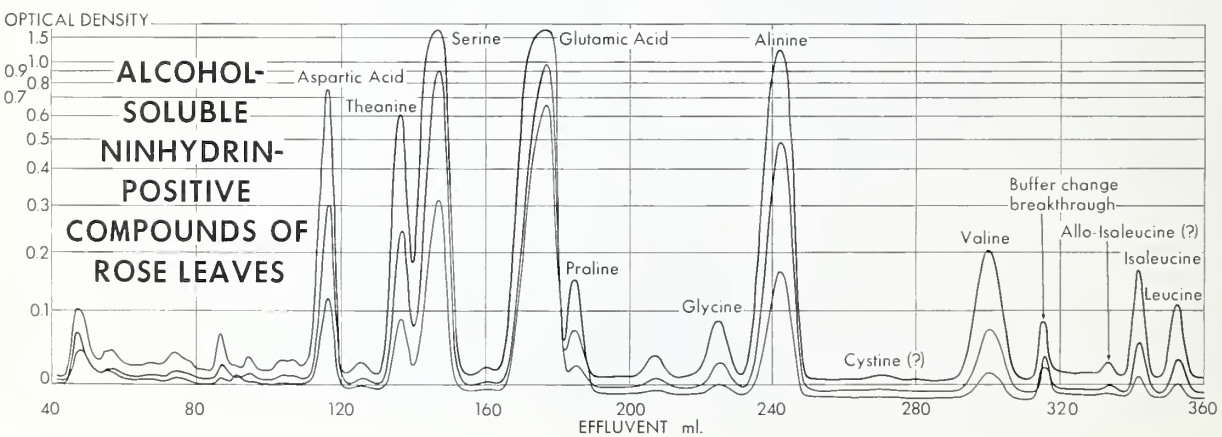
LABORATORY RESEARCH AND INSTRUMENTATION

Basic laboratory research is a forerunner to development of better field practices in soil and water conservation. Such research develops better understanding of physical and chemical processes occurring in soils. Properly interpreted to field conditions, such research often points to changes in tillage, fertilization, cultural, or other management operations.



Essential for this type of program is modern and often complex research equipment such as the electrochromatographic apparatus. This instrument automatically and quantitatively analyzes solutions for content of electrically charged organic and inorganic ions or elements in solution.

This is an automatically recorded amino acid analysis of organic material extracted with alcohol determined with modern analytical equipment. The peaks on the chart show not only what materials are present but also the relative amount of each. Such data are useful in understanding organic matter decomposition and the intermediate products formed in the process. This knowledge permits better interpretation of the effects of organic matter and its decomposition on soil physical properties and on the release of plant nutrients.



Combined field and laboratory studies of zinc nutrition and fertilization have been a major research undertaking in the Columbia River Basin. Deficiency symptoms of various crops have been characterized; zinc fertilizers, rates, and methods of application have been developed. This picture shows zinc deficiency of hops in the Yakima Valley. Such deficiency can be corrected to give growth comparable to that in the background by applying zinc fertilizer according to recommendations developed throngh research.

This is the zinc analysis laboratory and equipment at Prosser, Wash. Here, soil and plant tests for zinc determination and for study of the chemistry of zinc in soils are developed or improved. Diagnostic soil and tissue tests are developed also in connection with zinc fertilization experiments in the field.

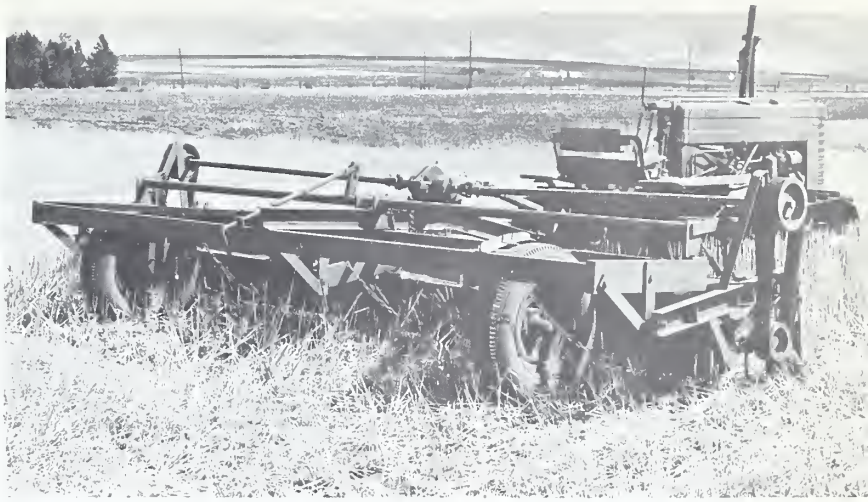
METHODS AND EQUIPMENT FOR STUBBLE MULCHING

The benefits of stubble mulching—surface management of crop residues—to control runoff and erosion have been well demonstrated. However, satisfactory operation of equipment has presented many problems. Extensive studies of these problems have been conducted in the Northwest, and operational methods have been developed to leave a mulched surface as shown here. Trash on the surface not only protects the soil from the beating action of rain but also makes the runoff water move downhill more slowly and prevents it from concentrating in channels.

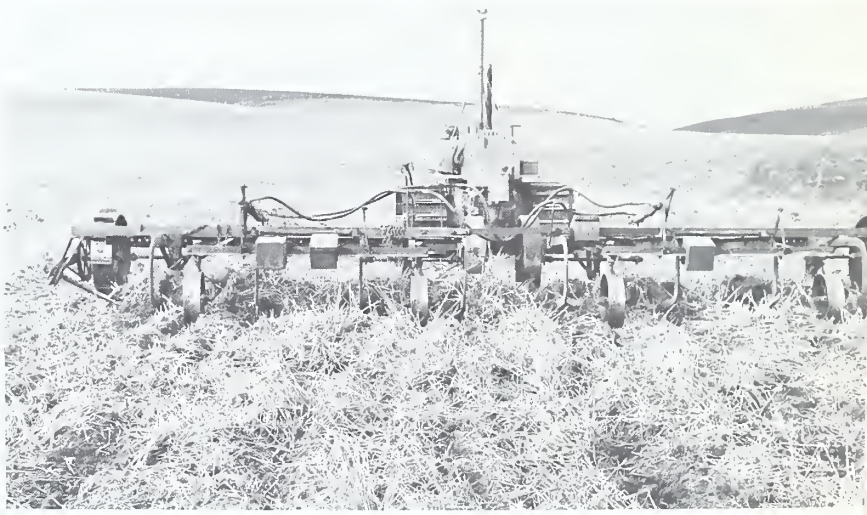
Newly developed subsurface sweep-type equipment, like the sweep plow shown here, is ideal for stubble mulching. Wide sweeps (6 to 9 feet) are most often used for initial tillage; narrow blades (24 to 36 inches) are preferred for later operations. The blade cuts through the soil 3 to 6 inches below the surface, kills weeds, and loosens the soil without burying crop residues.

One key to successful operation where residues are heavy, which is typical in the Northwest, is high clearance as shown on this duckfoot cultivator. In general, 24 inches or more clearance between the tillage point and implement frame is required to prevent clogging of residue in the equipment. Staggering of tool shanks on two or more frame members also helps let the residue slide between shanks.

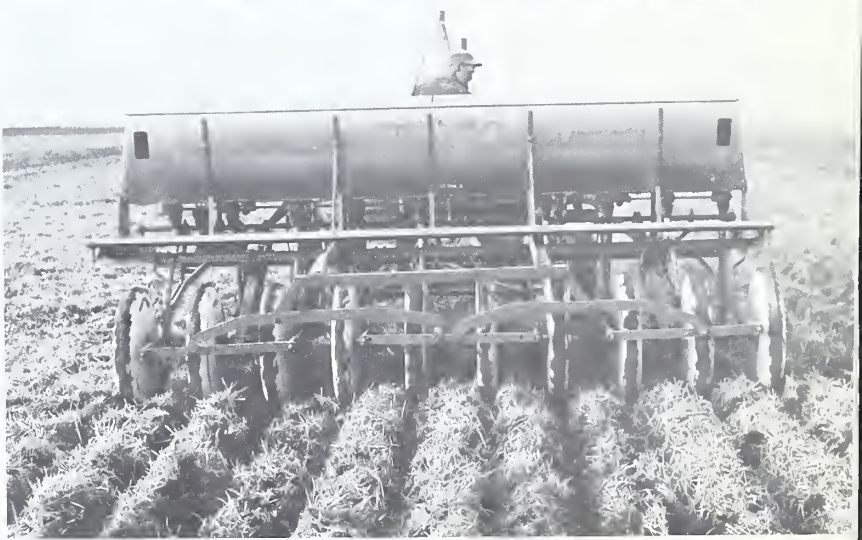
Where residues are extra long and heavy, pretillage use of "stubble-busters" such as this power-takeoff-operated rotary beater shortens the straw and prevents future troubles. Skew treaders, spike-toothed harrows, stubble cutters (mowers), and other types of stubble-busters have been used successfully for this purpose.



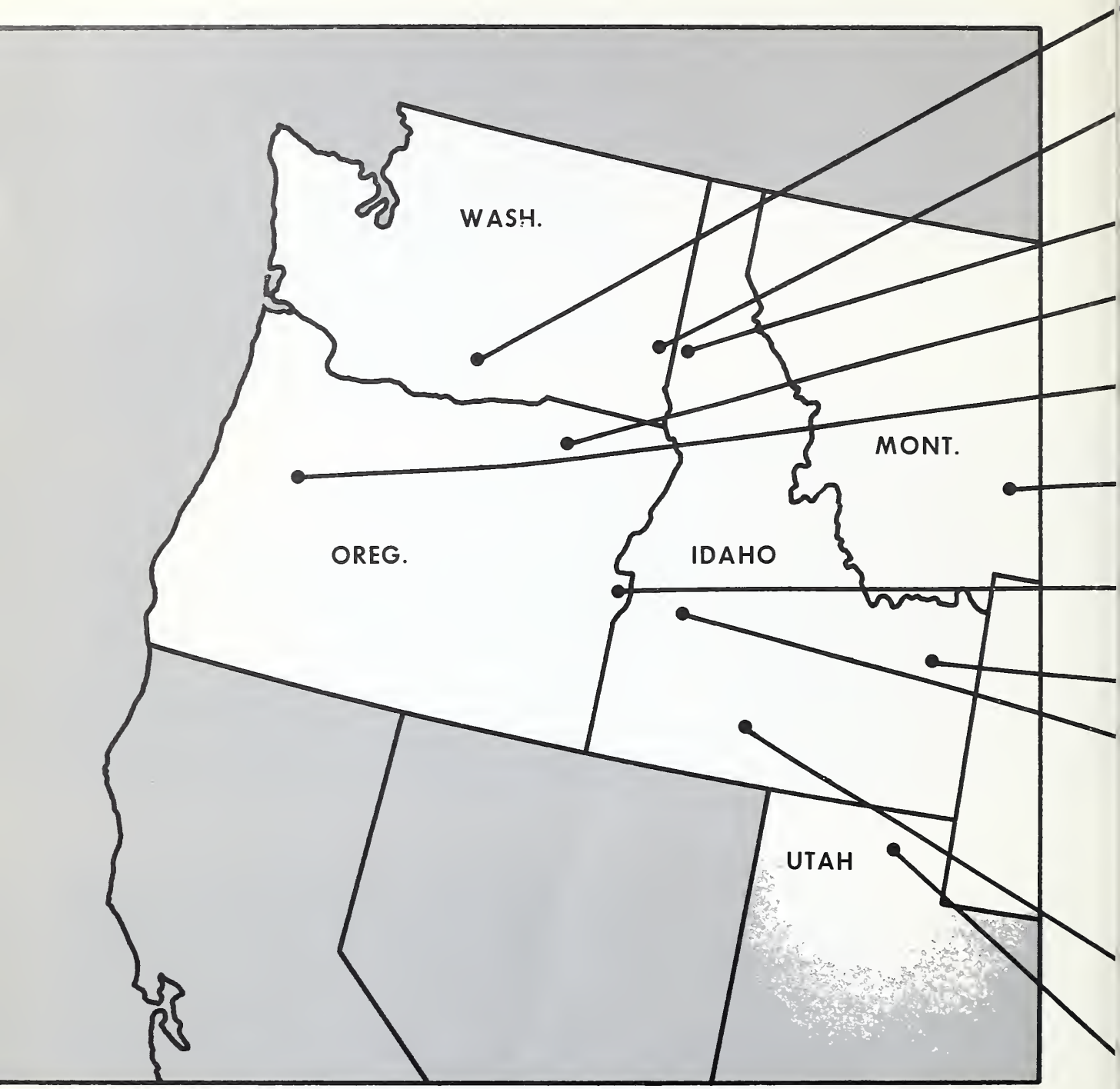
The rodweeder is a key implement in stubble mulching where a one-way disk or wide-sweep equipment is used for initial tillage. This high clearance, end-drive machine is ideal for killing small weeds, firming the seedbed, and maintaining residue on the surface.



Proper drilling equipment such as this deep furrow, high clearance shovel-type implement provides the final touch. Research has demonstrated that wider row spacing (12 or 14 in.) and deeper planting to place seed in moist soil leave a desirably ridged condition. Residues are evenly distributed on the ridges where they give erosion protection but do not smother the crop.



RESEARCH LOCATIONS



Prosser

Irrigation Experiment Station.
Soil microbiology, chemistry, and physics research on irrigated lands of central Washington.

Pullman

Soils Department, Washington State University.
Studies of cropping, tillage, and fertilization practices related to erosion and runoff in the Palouse; basic laboratory investigations of erosion mechanics.

Moscow

Agricultural Engineering Building, University of Idaho.
Watershed engineering investigations emphasizing hydrologic data analysis.

Pendleton

Pendleton Branch Experiment Station.
Studies of tillage practices, residue management, and moisture-fertility relationships on Oregon–Washington wheatlands.

Corvallis

Soils Department, Oregon State University.
Basic laboratory investigations of organic matter decomposition and nitrogen transformations in soils.

Bozeman

Soils Department, Montana State College.
Moisture conservation and moisture-fertility research on range and croplands; investigations of tillage practices.

Ontario

Malheur Branch Experiment Station.
"Slick-spot" reclamation studies on irrigated lands of eastern Oregon and western Idaho.

St. Anthony

Post Office Building.
Tillage, crop sequence, and fertilizer studies on eastern Idaho wheatlands.

Boise

Eastman Building, 105 N. 8th Street.
Northwest Branch headquarters, administrative office for Soil and Water Conservation Research Division program in Washington, Oregon, Idaho, and Alaska.

New York Life Insurance Building, 306 N. 5th Street.
Reynolds Creek Experimental Watershed headquarters, center for Northwest watershed investigations; sprinkler, border, and furrow irrigation system design studies; development of automatic irrigation devices.

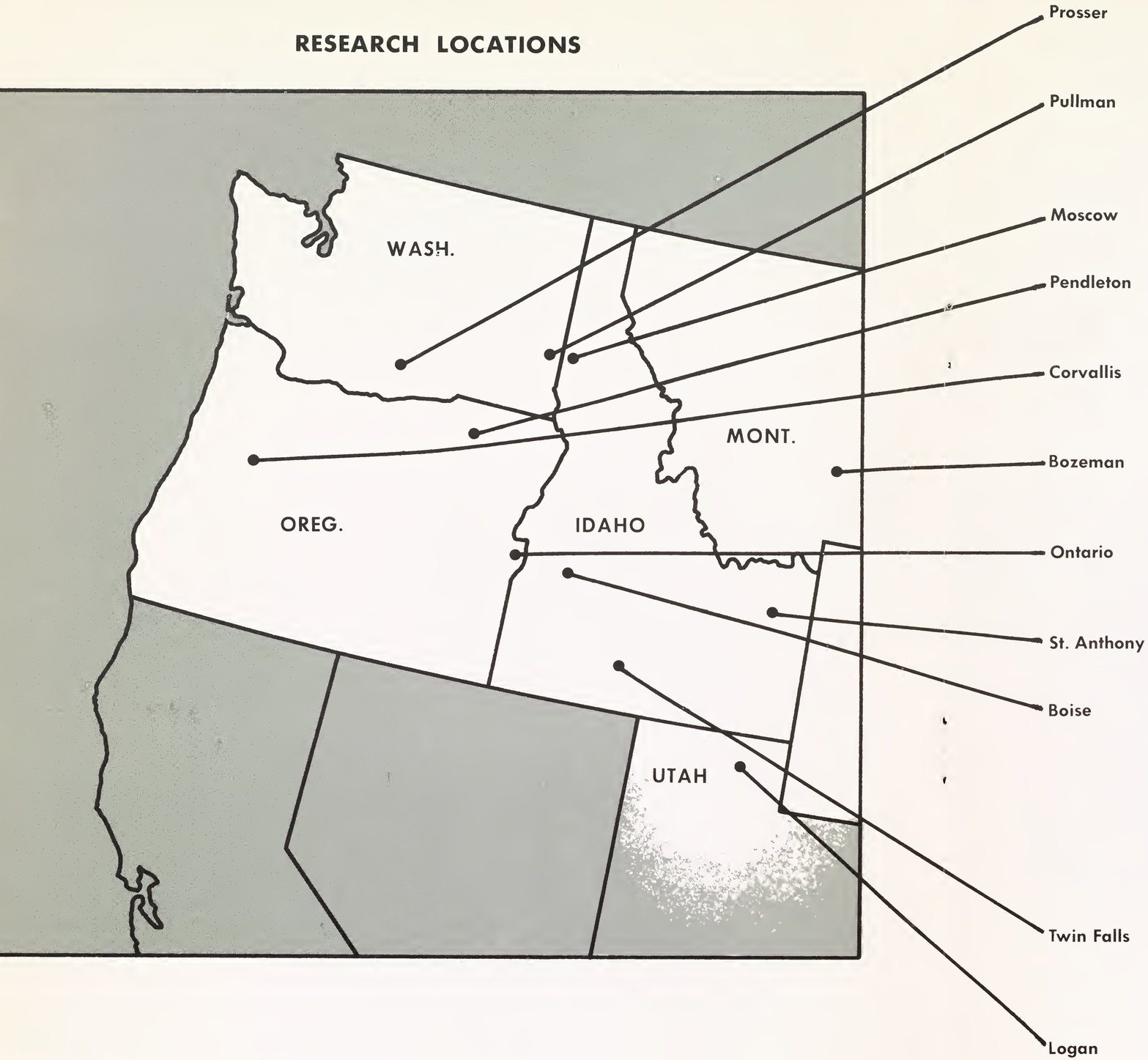
Twin Falls

Snake River Conservation Field Station.
Construction funds allocated in 1960; anticipated completion in 1963; projected program involves wide variety of soil and water research on both irrigated and nonirrigated lands of the Snake River Plains.

Logan

Engineering Department, Utah State University.
Irrigation water management, seepage control, and soil fertility studies on irrigated lands of northern Utah and southern Idaho.

RESEARCH LOCATIONS



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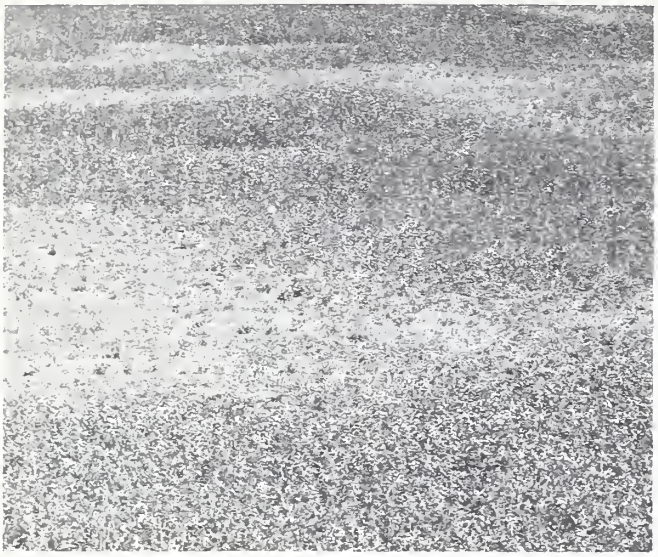
SLICK SPOT RECLAMATION



The "slick spot" soil condition on irrigated land in western Idaho and eastern Oregon adversely affected yields in a field of red clover near Caldwell. Idaho. Moisture penetration and root development of crops are greatly reduced because of high sodium content and dense layers in the soil. The condition occurs as patches in fields and often 30 to 50 percent of the field is affected.

Small plot experiments to test and evaluate reclamation treatments showed that deep mixing of the soil was highly beneficial. One of the treatments. as shown here during preparation. consisted of deep mixing of the soil to a depth of 3½ feet. Other methods included shallow mixing (22 inches) and the addition of gypsum.

Alfalfa-grass mixture on this untreated plot yielded less than ½ ton per acre in the first full cutting year. Stands were fair, but second cutting (shown here) and third cutting yields were extremely low. Water penetrated only 1 or 2 inches into the soil, even where standing water remained on the plot for several days. The crust became very hard upon drying.

Alfalfa-grass mixture on this shallow-mixed plot, with 20 tons of gypsum per acre added, yielded 9 tons of air-dry hay in the first full cutting year. Yield of the second cutting (shown here) was 2.6 tons per acre. Water penetration was excellent and the sodium content of the soil was reduced by irrigation water passing through it. All plots that were either deep or shallow mixed and where gypsum was added produced hay crops comparable to those on adjacent soil not affected by the slick spot condition.

Success of soil mixing in the plot experiments indicated the feasibility of deep plowing such lands to eliminate the slick spot condition. Here, a 4-foot moldboard plow pulled by a large track-type tractor is breaking the soil to a depth of 30 inches. Cost of this operation was $25 per acre. Experience on other soils shows a cost of $20 to $40 per acre, depending on depth of operation and hardness of the soil.

Fall irrigation is desirable to reconsolidate the soil and leach out salts. Water penetration and subbing between furrows is much better on the deep-plowed area on the left than on conventional seedbed to the right.

Spring wheat growing on unplowed slick spot near Ontario, Oreg. Yield on the unplowed portion of the field was 23 bushels per acre. Yield of spring barley on a similar unplowed area was 30 bushels per acre.

Spring wheat on deep-plowed part of the same field yielded 73 bushels per acre. Ordinary field irrigation and management practices were used over the entire field. Spring barley on deep-plowed portion of the field yielded over 100 bushels per acre.

Runoff of snowmelt or rainfall on frozen or wet soils is a serious problem in the Pacific Northwest. Not only is badly needed water lost from the field but serious soil erosion and sediment deposition usually accompany such runoff. Major research effort is underway to find practical solutions to this problem.

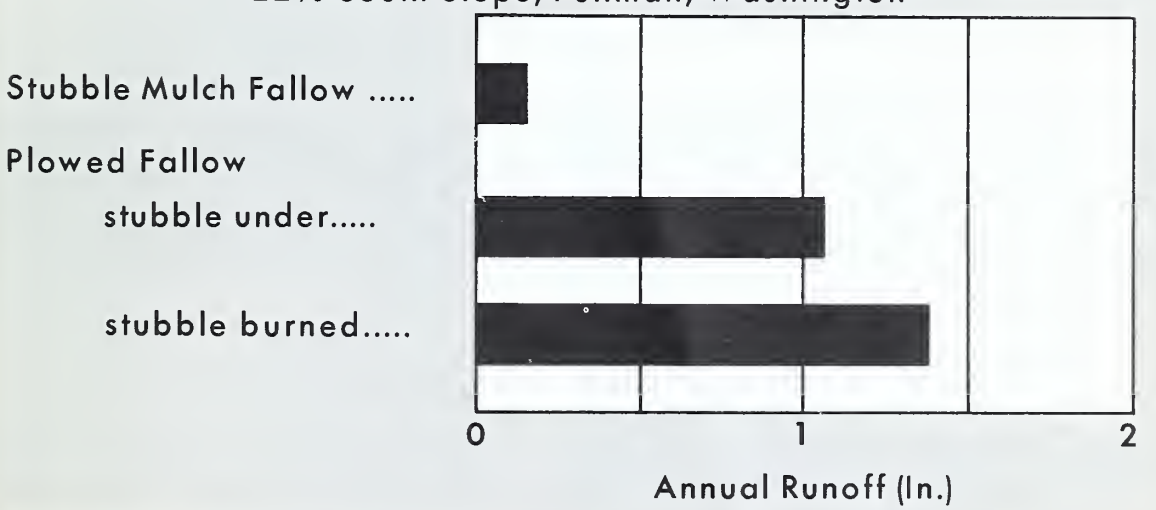
Rotary subsoiler pits shown here are filled with water from rapidly melting snow. Soil moisture storage under such treatment has increased 3 to 5 inches during the first winter after harvest when soil was frozen at the time of snowmelt. Subsoiling of seeded wheat also shows promise, but benefits of this practice have not been adequately measured. If soil is not frozen during the snowmelt period, moisture storage is generally not improved by subsoiling treatment.

Response to fall chiseling of annual cropped spring wheat was 13.2 bushels per acre in this experiment. Four years of results show average yields of 13.6 bushels per acre for annual cropped spring wheat, 16.7 bushels per acre for annual cropped spring wheat with fall chiseling, and 21.0 bushels per acre for wheat after fallow. Marked response to chiseling was obtained in 2 of the 4 years.

Stubble mulching is another method under study to reduce runoff from frozen or wet soils. These data from Pullman, Wash., show the runoff reduction obtained from this practice as compared with moldboard plowing and plowing after burning of stubble.

STUBBLE MULCH AND RUNOFF

22% South Slope, Pullman, Washington



SEEPAGE CONTROL METHODS AND MATERIALS

Loss of precious irrigation or livestock water by seepage from ponds, canals, or farm ditches is a critical problem in the arid and semiarid West. Stopping these losses and at the same time improving handling efficiency and control of agricultural waters remain a prime challenge to soil and water researchers.

Concrete ditch lining has long been the standard for preventing seepage losses. Its major drawback has been the high cost of both materials and installation. To reduce installation costs, scientists and engineers have developed a so-called "slip form" machine, which greatly lowers labor costs and replaces metal or wooden forming materials previously used. Furthermore, this method produces a much smoother and more uniform ditch.

Even with the most modern methods of installation, the cost of concrete linings is often too high to be practical. This has led to development and testing of a wide variety of cheaper materials such as the asphaltic membrane shown here. All sorts of materials have been tried: Soil cements, clays, asphaltic mixtures, rubber linings, plastics, and waxes. Less widely tested has been the addition of chemicals to the water. These chemicals move into the soil with the water and either chemically or physically alter the soil to reduce seepage.

Another development in irrigation research has been use of flexible tubing in place of open ditches to carry water on the farm. This butyl rubber tubing has small attached tubes which serve as outlets to introduce water into furrows. In addition to the advantage of lower initial cost and portability, this method avoids loss of land for an irrigation ditch, eliminates land leveling required to provide the slope for a ditch, and eliminates the evaporation and seepage losses of an open ditch.

Control of seepage from irrigation reservoirs and stock ponds is a related problem under study. The problem is especially critical in drier range areas where stock water must be held for several rainless months to fully utilize range vegetation. This picture shows a black plastic lining being installed to seal an excavated stock pond in Utah. Evaporation control by chemicals or even floating plastic sheeting has been tested in combination with seepage control.

WATERSHED HYDROLOGY

An important source of irrigation and stock water in arid and semiarid regions is the sagebrush-rangeland zone at intermediate elevations. This zone lies between the high water producing area where snowfall is heavy and the lower elevation irrigated areas. Scientists study the relations between the climatic characteristics such as precipitation, wind, solar radiation and the watershed characteristics of geology, soils, vegetation, topography, and elevation. These characteristics are in turn related to rates and amounts of water yield and sediment production.

Agricultural Research Service activities in watershed engineering in the Northwest Branch are centered in the Reynolds Creek Experimental Watershed in southwest Idaho. This program, initiated in 1960, emphasizes studies of factors influencing water yield and sediment production from sagebrush-rangeland areas.

The wealth of the irrigated farm lies in the water stored in the snowpack during winter precipitation. Snow accumulation is measured periodically at selected sampling stations to determine water content, deposition patterns, and melt rates under various conditions of slope, elevation, exposure, and vegetation. After basic data are collected, further studies will be made to investigate management practices that might influence the amount of snow deposited at any one location as well as practices that might change the time of melt to meet irrigation needs better.

A network of recording rain and snow gages determines precipitation characteristics under varying conditions of elevation, slope, and aspect. These gages provide continuous record of rates, amounts, and intensities of precipitation.

Accurate measurements of rates and amounts of streamflow are a necessity. Engineers make current meter measurements at various stages of flow to determine channel characteristics and develop a stage-discharge rating curve for selected locations. Current meter stations are carefully selected at points with smooth, uniform flow and constant channel shape and size.

In association with the current meter measurements, continuous records of water stages are maintained at temporary stream gaging locations. These stations provide data on instantaneous rates of discharge as well as volumetric amounts of water yield for any desired time interval. Stations such as this will be maintained only until permanent, accurate streamflow measuring structure can be constructed in the channel.

A complete water balance study of an area requires that irrigation diversions be measured. A Parshall flume is installed near the point of diversion and continuous records of diverted water are maintained. These flumes, placed in tandem in a ditch, also measure seepage losses in the distribution system.

An important consideration in studying water yield is the geologic characteristics of the area. By using a drill rig that will bring up samples from more than 250 feet below the surface, the geologist can determine location of water bearing strata, subsurface hydrologic divide, and related information. Drill hole information is also valuable in studying foundation conditions for streamflow measuring structures.

Movement of underground water is studied by pumping tests which measure the drawdown and recovery of water levels. In the pumping test pictured here, water level elevations are being continuously recorded in adjacent test holes located a few hundred feet from the primary test holes.

Surface geology is intensively mapped. The geologist studies all surface formations to develop the relations between the surface and subsurface explorations. A complete inventory of geologic conditions is essential to determine the influence of geology on water yield.

Soils play an important part in the water yield of an area. Here, a soil scientist examines a sample obtained from a pit dug to study soil development and profile. Field studies such as this are used in conjunction with laboratory analysis to determine the infiltration rates, water holding capacity, and erosive potential of soils.

SOIL FERTILITY AND PLANT NUTRITION STUDIES

When plants do not get enough essential food elements, they will not attain maximum growth. Under such conditions, efficiency in use of land and water resources is less than where needs of the plants are met. Therefore, an important part of the total research effort is determining the nutrient needs of crops grown on various soils under a wide variety of crop rotations, climatic conditions, and management practices.

In this fertility research, emphasis is placed on development of nutrient diagnostic techniques, especially those to determine whether or not nutrient levels are adequate. Balancing nutrient supplies with available water and energy is also of major concern, especially on nonirrigated lands.

In this field experiment, extensive leveling removed topsoil on land in the Columbia River Basin in Washington. Differences in growth of the potatoes resulted from application of various amounts of phosphorus and zinc.

This potato plant shows typical zinc deficiency symptoms, commonly known as "fernleaf." Studies have shown that this condition cannot be corrected by zinc fertilization alone, either through soil or foliar application. Application of phosphorus alone makes matters worse and, with high rates commonly used on potatoes, the plants die without producing marketable tubers.

"Fernleaf" can be corrected by applying *both* phosphorus and zinc to the soil. Plants in the foreground received phosphorus alone; those in the back phosphorus and zinc.

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